

Reducing Indoor Noise Levels Using People's Perception on Greenery

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Abstract – Employees working in cubicles of open-plan offices in Indonesia were studied in regard to their perception on the ability of indoor greenery to reduce noise levels. *Sansevieria trifasciata* and *Scindapsus sp* were used. Each was placed in the cubicle and noise levels were measured without plants, with *Sansevieria*, and with *Scindapsus* in place. The meters showed very insignificant difference. However, responses to surveys indicated a perception of lower noise in the presence of greenery. This seemed to be supported by prior knowledge and preconception and may be useful in creating a “quieter” indoor environment.

Keywords - Cubicle rooms, indoor greenery, noise levels, people's perception

I. INTRODUCTION

Indoor noise levels in some offices could be as intolerable as those outdoors, since indoor levels are the accumulation of outdoor noise intrusion and indoor noise. There are several noise issues in open plan offices, such as speech privacy between locations which is masked by ambient noise level or the opposite; the need of higher pleasant ambient noise by means of sound systems to mask private speech [1]. These two issues should not be an issue in an ideal office environment where each employee focuses on their own work and does not disturb others by having conversation except in the meeting room. When formal discussion is required, it shall be conducted in a designated meeting room and private discussions shall be conducted somewhere else but in the office. A more important noise issue in open plan offices is the level of distraction or annoyance from either ambient or background noise which potentially split an employee's concentration between his/her job and non-job activities.

For those working in cubicles of open plan offices, the source of noise is usually more complicated than in single offices. In a single office, indoor noise may be generated by HVAC systems and office equipment such as, telephones, computers, printers and faxes. More noise sources are experienced in an open plan cubicles office, such as footsteps and speech from adjacent or far cubicles. Those working in cubicles may get privacy from visual distractions, but not from the noise of adjacent or far cubicles, as sounds easily disperse over cubicle walls. A common solution to attenuate ambient indoor noise is the installation of absorbent linings on to the wall, floor and ceiling. However, for buildings in warm humid climates, this is not an ideal option; since absorbent linings usually made of soft fabric or material may easily be dampened

by the humid-air. In long-term use, humid linings may generate unpleasant odor and trigger the emergence of mould.

By this issue, usage of alternative material to reduce indoor noise levels was studied. The proposed absorbent material was indoor greenery. Nomination on usage of greenery was supported by earlier studies on outdoor noise and vegetation. Li et al [2] confirmed insignificant attenuation of noise annoyance at home which is below 7 dB by surrounding greenery. This finding is debatable since terminologies of ISO 717 Rating of Sound Insulation for Dwellings and ASTM E 966 Guide for Field Measurement of Airborne Sound Insulation of Building Facades and Facade Elements did not seem to be referred to by this research. Aylor [3] confirmed that corn crop reduced noise propagation by 5 to 6 dB. This is similar to that of Samara et al [4] who concluded that a *Pinus brutia* belt of trees reduced traffic noise by 6 dB. Bernatzky [5] marked that greater noise attenuation of 12 dB was offered by parks. Moreover, Pathak et al [6] revealed that *H. rosinensis* reduced noise at both low and high frequencies of 26 dB, *M. peniculata* of 20 dB, *P. roxburghi* of 17 dB and *C. nocturnum* of 14 dB. Findings of [3] to [6] are debatable, since they require deeper analysis on whether it was greenery or distance that reduced the noise.

The ability of vegetation to reduce noise was also studied by Costa [7] who confirmed that indoor greenery of *Philodendron scandens* had a significant sound absorption coefficient of 0.72 at the maximum frequency of 4000 Hz. Wong et al [8] also revealed that such denser vertical greenery provided relatively better insertion loss than the rest of the tested greeneries. Such vertical greenery of 100% density provided a sound absorption coefficient of up to 0.5 at the maximum. Regardless of values of dB attenuation and sound absorption coefficient, all these studies indicated that vegetation has a capability of reducing noise. However, Mulligan et al [9] confirmed that loudness increased as the percentage of visible vegetation increased. Whilst, Watts et al [10] proved that the visual attractiveness of vegetation did not appear to benefit noise sensitivity. Renterghem et al [11] had also shown that the computational simulation of the vegetation belt was insignificant in reducing noise, ranging from below 1 dB up to 3 dB.

Studies of [2] to [11] have triggered the reported study to learn more on whether sound reduction by greenery has solid findings or more to people's perception. The reported study was conducted indoors; a more controlled environment compared to those of outdoors. This was aimed to minimize factors of abrupt weather fluctuations such as wind speed, wind direction, air temperature, and humidity. The limited space of the indoor environment was also aimed to eliminate factors of distance which have significant effect on the actual noise

attenuation. Usage of vegetation to substitute commonly used indoor linings was proposed since earlier research confirmed that greenery might improve indoor air quality by absorbing air pollution [12, 13, 14] and may benefit as a possible solution to the global warming issue.

II. OBJECTIVE

There were two objectives of this study. First, it was to study whether there is any significant noise level degradation attributable to the installation of indoor greenery. The study took place in open plan cubicle offices as representation of indoor environment. Research within the controlled indoor environment was proposed to minimize non-greenery factors that may mask the noise degradation process. An open plan cubicle office was selected since occupants of this indoor environment experience potential noise annoyance. The second objective of the study was to study employees' prior knowledge, preconception and perception on the usage of greeneries. At the end, the study was expected to explain whether the actual noise reading by sound level meter correlates to noise annoyance experienced by employees.

III. THEORETICAL APPROACH

It is showed by studies of [2] to [11] that evidence of greenery in reducing noise is still debatable. When it is brought to deeper analysis, we may see that even though there was noise reduction during greenery, the reduction was very insignificant. It mostly ranged below 1 dB to 6 dB. Sound fluctuation below 7 dB is off the human's auditory sensitivity [15, 16]. Thus any noise level degradation below 7 dB is considerably negligible to a human. In the case when people declare of significant noise level reduction, whilst according to the measuring equipment it is very insignificant; we may suspect that it may only be of people's perception.

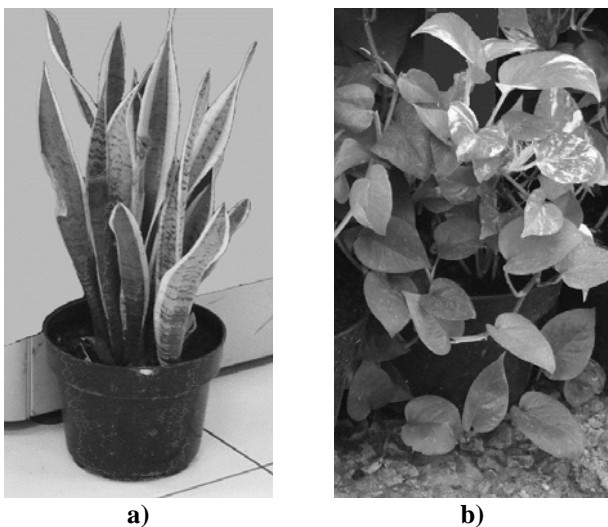


Fig. 1. a) *Sansevieria trifasciata* and b) *Scindapsus sp*

Capability of greenery to absorb or reduce noise may be supported by the nature of plants that consist of leaves with

unique surfaces covered by stoma and delicate hair [17]. Thus properties of plants are similar to those of absorbent linings, such as carpets and soft perforated panels commonly used in buildings. The porous surface of these objects offer significant absorption coefficient at high frequency sound [18]. Both research by Costa [6] and Wong [7] also confirmed that vegetation possesses great absorption coefficient at higher frequency. It is because sounds at low frequencies are of longer wavelength [19] which could not be absorbed by such tiny leaf and stoma. Stomas and hairs are very delicate, thus theoretically it will only have the ability to absorb high frequency noise; noise that is not entitled vibration.

To study deeper on whether plants have the capability to reduce noise or it is more due to people's preconception and perception, a study on the use of greenery in two Indonesian offices is reported here. Two types of plants that are commonly used as indoor greenery in Indonesia and are easy to maintain were selected. They were *Sansevieria trifasciata* and *Scindapsus sp* (Fig.1). *Sansevieria* represents thick, stiff and ribbon-like leaves, whilst *Scindapsus* is the opposite: thin, soft and round-shaped leaves. Both are robust plants; almost independent to sun exposure and insignificant water demand. That is, the selected greeneries are suitable to be kept indoors. The *Scindapsus* may be kept indoors all the time, whilst *Sansevieria* requires sun exposure once a month for approximately one or two days and may be brought back indoor afterwards.

IV. METHODS

The study was conducted empirical to study both the actual indoor noise levels before and during greenery and the employees' prior knowledge, preconception, and perception on greenery installation. Field measurements on ambient indoor noise and questionnaire-type surveys were conducted to collect the data. The surveys were carried out with a printed questionnaire to be filled by respondents. During the collection of filled questionnaires a checking of errors was conducted. That is, when error or bias answers were suspected, a personal interview was carried out.

Employees working in two open-plan offices were the focus of this study. They were administration officers at the Faculty of Engineering of Atma Jaya Yogyakarta University (AJYU, Fig.2 and Fig.4) and employees at Design Graphics and Mechanical Engineering Department of Alstom Power Surabaya (Fig.3 and Fig.5). The first office represented a working environment with significantly high tolerance to noise and annoyance as one of employees' job description was customer service for students and lecturers. The second office represented a more private and individual job description and thus lower tolerance to noise annoyance and distraction. Both offices were air conditioned and thus no openings existed.

At the first stage, existing noise levels within the two offices were measured. Then, the second measurement was with *Sansevieria* installed and the third with the *Scindapsus*. Each plant of approximately 80 cm height was planted in a medium container, with 1 container for 1 cubicle. Since *Scindapsus* is a

type of climbing plant, it requires a frame to grow on a container. A timber stick of 80 cm height was placed on the container for the plants to climb around. It took approximately 6 months to prepare the climbing greenery and mature *Sansevieria*.

As in Fig.2 and Fig.4, there were 10 occupied cubicles in AJYU office. Each cubicle has direct access to 1 container. For the entire room, 18 containers were placed. Fig.3 and Fig.5 describes cubicles layout and greenery installation of the Alstom office. Here, 49 cubicles were available, but only 31 were occupied. Those without greeneries were unoccupied. The number of containers placed in the office was based on the availability of sufficient space for circulation and movement. That was limited to 18 containers in the AJYU office and 34 in the Alstom office. Any more plants was considered too tight for employees' movement and circulation.

In both offices, 3 Sound Level Meters (SLM) were installed to measure actual ambient noise levels. Three SLMs were considered sufficient to record the ambient noise of the entire room. By using 3 SLMs all together, we might control reliable data reading from one to another SLM [20]. The difference in room dimension of AJYU office which was 7.00 x 9.50 m² and Alstom office which was 14.00 x 18.00 m² resulted in a difference in where the SLMs were placed in each office. In Alstom, they were installed linearly through the main corridor which was located approximately in the middle of the room, each 4 m from one another. Whilst in AJYU office, they were set triangularly, each 4 m apart from one another. The potential noise source of this office was from the receptionist counter where employees served customers. Thus, 2 SLMs were put close to the potential source and 1 was put approximately in the middle of the room. Sound pressure levels of ambient noise were collected using conventional SLM, DEKO – Type SL 130 digital. This is a class 2 SLM (previously type 2), refers to IEC [21]. Class 2 is general purpose instruments for field use, including measurement of noise at work, with tolerances lie between the old type 1 and type 2. Tolerance for class 2 is ± 1.3 dB with ± 0.3 dB included uncertainty; operated in temperature limit of 0 °C to +40 °C.

The SLMs were brand new ones and have been manufactory pre-calibrated. They stood on 120 cm height tripods and were set in A-weighting network reading (Fig.6). Each group of data collection was conducted in 3 working days during working hours, limited to 30 minutes after it starts and 30 minutes before it ends. Thus it was 9 days sum in each office. The first and last 30 minutes were not recorded to give sufficient time for employees to be ready for work and to prepare for leaving. This was considered as a transition time between arriving and leaving, and was notified as noisier than the rest of the day during pre-surveys. Noise during transition time was higher as employees tend to have chat amongst themselves. As the SLMs were conventional (not integrating-averaging), the reading was taken sequentially every 15 minutes after the meter was on. Operators did not stand close to SLMs during data recording as human body may reflect sound and thus generating non-valid noise recording [20]. They stood close to the meter only when collecting data from the SLMs' screen. Sequential data

collection of each 15 minutes during 7 hours; means 28 recorded data; was considered to provide more actual data than that of one L_{eq} during 7 hours, which means 1 data only. This setting would also allow operators to have more control on the running equipment whether it worked properly, running error, or battery critical.

Along with the noise reading, questionnaires were collected from all employees in the two offices, before and during the installation of greeneries. There were 10 employees in the AJYU office and 31 in the Alstom office -- a total of 41 respondents. The questionnaire was constructed sequentially. First was to gain personal data of employees and their employment which is gender, age, and period of service. Second was the judgment on noise annoyance in the existing condition, which consists of judgment of noise levels, level of annoyance, type of noise source, and expectation on the room's improvement. Third was prior knowledge and preconception on greeneries' ability in reducing noise. Fourth was judgment on noise annoyance during installation of greenery. The first and second sequences were asked prior to placement of greenery and third and fourth were asked during the time when greeneries were placed. As this study was mostly related to numerical noise and opinion on noise, the questionnaire could not be constructed using the common Likert's scale fully. However, the questionnaire was developed as close as possible to the Likert's scale, which is rated from the level of disagreement to agreement. Likert's scale is a widely used scaling to measure people's judgment on such issues. It usually ranges from "strongly disagree" to "strongly agree" on such issues. It is scored from 1 to 5 or 1 to 7 for more detail. One is scored for those who "strongly disagree" and 5 or 7 are for those who "strongly agree".

There were dependant and independent variables appointed to construct the questionnaire. Dependant variable was judgment on noise annoyance, both existing and during greenery installation. Whilst the independent were gender, age, period of service, level of distraction, expectation on the room's improvement, prior knowledge on greenery, preconception on greenery, and judgment on greenery installation. The last two variables were considered as variables that constructed the respondents' perception.

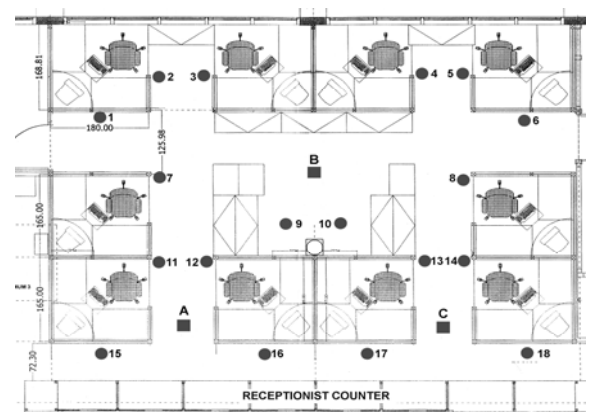


Fig. 2. AJYU's office layout plan and greenery setting, with ● is greenery and ■ is Sound Level Meter

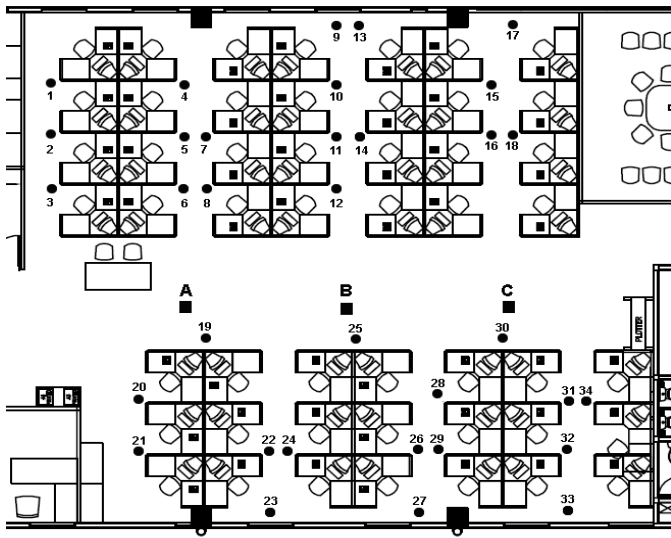


Fig. 3. Alstom's office layout plan and greenery setting, with ● is greenery and ■ is Sound Level Meter. Cubicles without greenery were unoccupied



Fig. 4. View of the AJYU office

As respondents were considered having limited knowledge on noise levels, the option of answers in the second sequence were designed to offer ease in picking the answer. Options regarding ambient noise condition were modified from decibel numeric to auditory sense which was varied from “very quiet”, “quiet”, “fair”, “noisy”, to “very noisy”. Options regarding indoor noise levels were also modified from decibel numeric to auditory and visual senses which was varied from “like the sound of a breeze”, “like conversation”, “like a scream”, “like a vacuum cleaner”, “like a highway junction”, to “like being adjacent to a moving train”. Level of distraction was modified from “always difficult to focus” on work task, “difficult to focus”, “fair”, “easy to focus”, to “always easy to focus”.

The validity and reliability was also tested. At first, pre-questionnaires were distributed to 5 employees other than

the respondents to be included in the study. This was to gain feedback to improve the questionnaire prior to the main survey. From here, several unclear statements were revised for further ease. Prior to the main analysis, answers of each question were scored and tested for their validity using statistical correlation formula.

By Table I, we found that 2 questions were not valid, thus were not to be included for further analysis. Reliability of the questionnaire was tested using Cronbach's Alpha (α). The α was 0.44 which is considered as fairly reliable [22]. Table I presents validity and reliability test and other statistical terms of the questionnaire result.



Fig. 5. View of the Alstom office



Fig. 6. SLMs setting in Alstom office

TABLE I
STATISTICAL REVIEW OF THE RESPONDENTS' RESPONSES

Statistic term	Gender	Age	Period of service	Judgment about existing noise annoyance	Judgment about existing noise levels	Level of distraction	Expectation on room's improvement	Prior knowledge about greenery	Preconception about greenery	Judgment about greenery installation	Judgment about noise annoyance during greenery installation
Mean	1.90	3.07	2.80	2.93	2.15	3.17	3.44	1.41	3.61	3.61	3.34
Standard Error	0.05	0.24	0.20	0.08	0.12	0.16	0.15	0.08	0.11	0.11	0.07
Median	2.00	3.00	3.00	3.00	2.00	3.00	4.00	1.00	3.00	4.00	3.00
Mode	2.00	3.00	3.00	3.00	2.00	4.00	4.00	1.00	3.00	4.00	3.00
Standard Deviation	0.30	1.56	1.25	0.52	0.79	1.00	0.98	0.50	0.70	0.70	0.48
Sample Variance	0.09	2.42	1.56	0.27	0.63	1.00	0.95	0.25	0.49	0.49	0.23
Kurtosis	6.24	-0.91	1.68	0.95	1.78	-0.80	-1.03	-1.97	-0.63	0.00	-1.60
Skewness	-2.82	0.21	0.87	-0.12	1.31	-0.04	-0.33	0.36	0.72	-0.18	0.69
Range	1.00	5.00	5.00	2.00	3.00	4.00	3.00	1.00	2.00	3.00	1.00
Minimum	1.00	1.00	1.00	2.00	1.00	1.00	2.00	1.00	3.00	2.00	3.00
Maximum	2.00	6.00	6.00	4.00	4.00	5.00	5.00	2.00	5.00	5.00	4.00
Sum	78.00	126.00	115.00	120.00	88.00	130.00	141.00	58.00	148.00	148.00	137.00
Count	41.00	41.00	41.00	41.00	41.00	41.00	41.00	41.00	41.00	41.00	41.00
Largest	2.00	6.00	6.00	4.00	4.00	5.00	5.00	2.00	5.00	5.00	4.00
Smallest	1.00	1.00	1.00	2.00	1.00	1.00	2.00	1.00	3.00	2.00	3.00
Confidence Level (95.0%)	0.09	0.49	0.39	0.16	0.25	0.31	0.31	0.16	0.22	0.22	0.15
r Data	0.30	0.72	0.63	0.41	0.27	0.34	0.31	0.37	0.61	0.23	0.42
r Table	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
Validity	valid	valid	valid	valid	not valid	valid	valid	valid	valid	not valid	valid
Reliability	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44

V. RESULT AND DISCUSSION

Continuous noise level measurements of 15 minutes each using 3 SLMs of 7 hours per day for 18 days produces hundreds of numerical data, which may lead to bias. It was 3 days for sound pressure level of the existing condition, 3 days with *Sansevieria*, and 3 days with *Scindapsus* in each office. There were 1,512 datas sum. This should be brought into one figure of L_{eq} of each group, which is before greenery, during *Sansevieria* and during *Scindapsus* of the AJYU office and similar to these of the Alstom office. L_{eq} is the preferred method to describe sound levels that vary over time, resulting in a single decibel value which takes into account the total sound energy over the period of time of interest. The L_{eq} of each group was calculated using (1) [23].

$$L_{eq} = L_{50} + 0.43(L_1 - L_{50}) \quad (1)$$

Each L_{eq} of 3 SLMs was then averaged statistically to represent L_{eq} of each group. The average values of each office are presented in Fig. 7 and Fig. 8. Both figures show that there was indoor noise level reduction, but it was very insignificant. In the AJYU office, noise reduction was approximately 4 dB,

but in Alstom office, it was less, which is below 1 dB. These differences are off audible range of human auditory sensitivity, so is impossible to physically create more comfortable noise conditions [15, 16]. This finding was not in line with Costa [7] and Wong [8], which might be caused by different noise spectrum or frequency or lesser greenery. However, considering availability of sufficient space for movement and circulation, adding more greenery in to the room seemed impractical. Existing ambient indoor noise level of Alstom with more private and individual type of employees was found to be higher than that of noise standard in an office. The standard is 50 dB maximum [23], whilst it was approximately 58 dB in Alstom. By post-surveys, it was found that HVAC seemed to be the potential source. Ambient noise level in AJYU with more distraction of customers entering and leaving the room was surprisingly found lower than the standard. We may learn that somehow particular type and installation system of HVAC created more noise than some other types.

Interesting phenomenon is to be discussed from the questionnaire surveys result. By Fig. 9, Fig. 10 and Fig. 11, we learn that respondents were between 36 to 40 years of age as a majority. Most of them were male with a period of service within the tested room of mostly between 2 to 3 years. There

were respondents of both offices with a period of service more than the mode and the mean, but in Alstom, this was not the case, since employees were relocated to a newer room 3 years earlier. Their judgment on the previous room was not considered in this study since the main consideration was respondents' judgment on noise annoyance in the existing room.

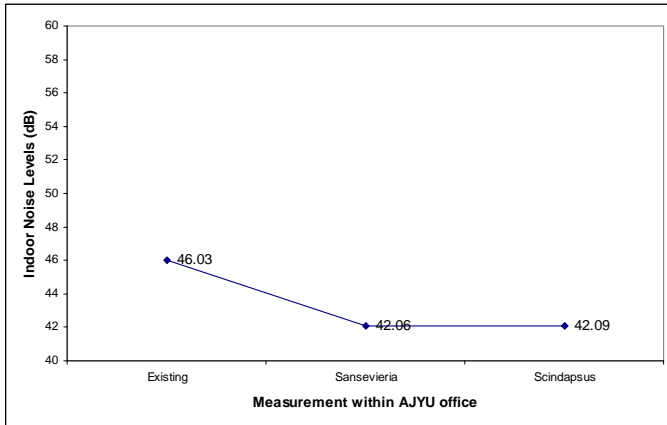


Fig. 7. Ambient indoor noise levels within AJYU office

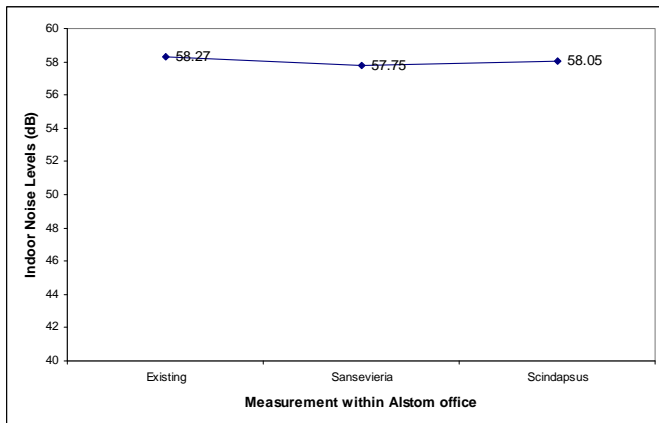


Fig. 8. Ambient indoor noise levels within Alstom office

By Fig. 12 and Fig. 13, we learn that most respondents judged the existing noise annoyance were categorized “fair” with “fair” level of distraction which trigger them to “easily focus” on their job description. Whilst by Fig. 14 and Fig. 15, the data confirms that most respondents “do not possess prior knowledge” regarding greenery reducing noise, but the mean shows more positive result which was 0.4 point over the mode. It is interesting to find that with tiny prior knowledge, on average they had the preconception toward “convinced” that greenery has the ability to reduce noise (0.6 point above the mode). Specific to AJYU office, it was the mode and the mean that respondents had perception toward quieter office during installation of greenery (Fig. 16). This slightly differs to that of Alstom. In Alstom the judgment was lower. It was only 0.3 point above the mode (Fig. 17). But still, it shows average toward “quieter” office. Overall, we may learn that both offices show average value similar to that of Alstom’s (Fig. 18). That

is, even in very low level, indication of perception on “quieter” office existed among respondents.

The findings of the questionnaire confirmed that perception toward a “quieter” office during placement of greenery was not supported by the metered noise levels. Respondents’ perception that was not in line with the meter might be supported by their preconception on greenery’s ability to reduce noise. It might also be supported by the question regarding respondents’ feeling toward greenery installation. By this question, 8 respondents out of 10 in AJYU and 20 respondents out of 31 in Alstom agreed that greenery created more pleasant view within room. However, as this question was found to have insufficient validity during the correlation test (Table 1), this might not be useful for deeper analysis.

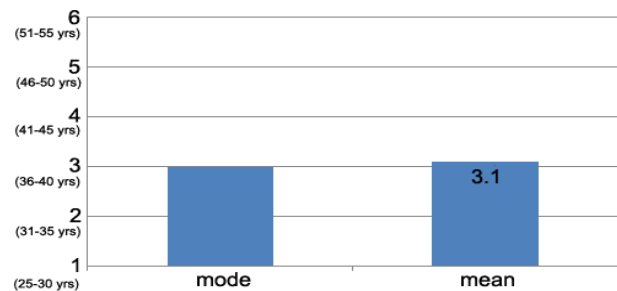


Fig. 9. Profile of respondents' age

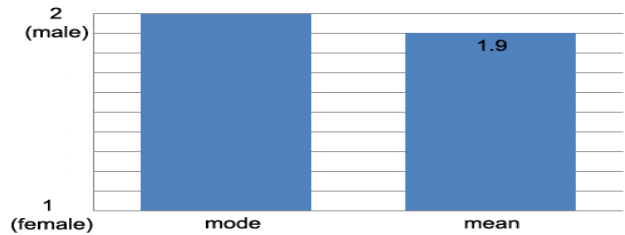


Fig. 10. Profile of respondents' gender

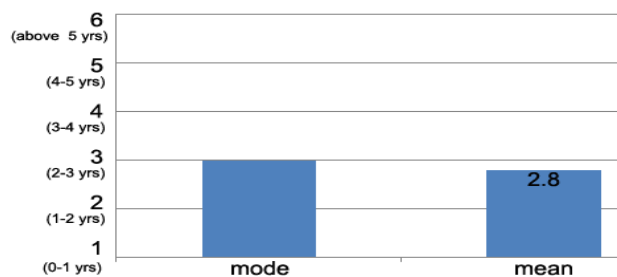


Fig. 11. Profile of respondents' period of service

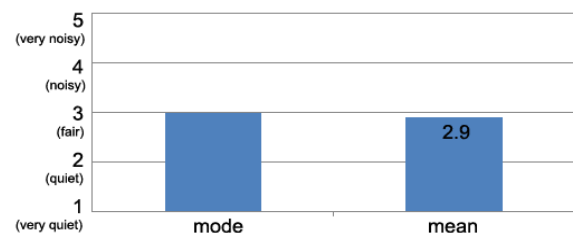


Fig. 12. Judgment about existing noise annoyance

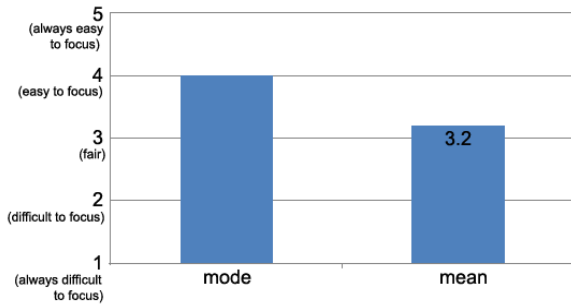


Fig. 13. Judgment about existing level of distraction

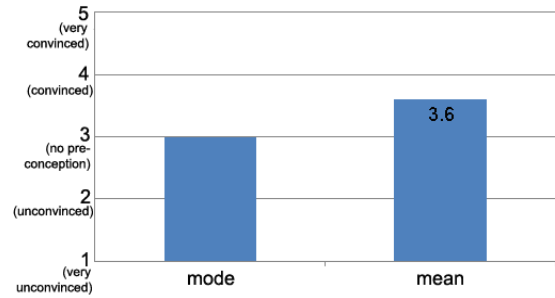


Fig. 15. Preconception on greenery's ability to reduce noise

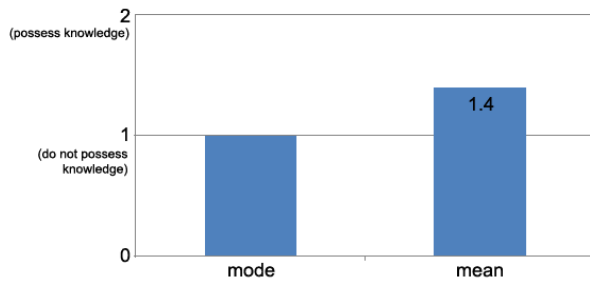


Fig. 14. Prior knowledge on greenery's ability to reduce noise

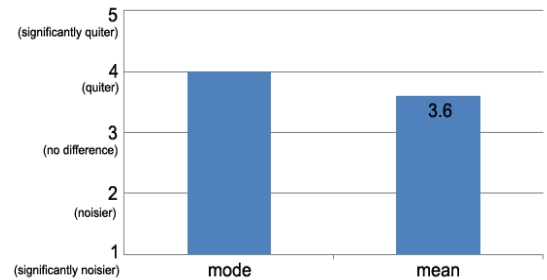


Fig. 16. AJYU office's judgment about noise annoyance during greenery

TABLE II
SCORING OF VARIABLE OF AGE IN ASSOCIATION WITH OTHER VARIABLES

Age (years)	Score				
	Judgment about existing noise annoyance	Level of distraction	Prior knowledge about greenery	Preconception about greenery	Judgment about noise annoyance during greenery
25-30	2.56	2.89	1.22	3.11	3.11
31-35	3.00	3.50	1.17	3.33	3.17
36-40	2.90	3.50	1.40	3.90	3.40
41-45	3.13	3.00	1.75	4.13	3.50
46-50	3.20	2.80	1.60	3.20	3.60
51-55	3.00	3.33	1.33	4.00	3.33
Range between min to max score	0.48	0.61	0.58	1.02	0.49
Significance (range more than 0.50 is considered significant)	Not significant	Significant	Significant	Significant	Not significant

TABLE III
SCORING OF VARIABLE OF PERIOD OF SERVICE IN ASSOCIATION WITH OTHER VARIABLES

Period of service (years)	Score				
	Judgment about existing noise annoyance	Level of distraction	Prior knowledge about greenery	Preconception about greenery	Judgment about noise annoyance during greenery
0 to 1	3.14	3.14	1.57	3.57	3.43
1 to 2	2.80	2.80	1.20	3.60	3.40
2 to 3	2.84	3.24	1.40	3.52	3.28
more than 5	3.25	3.25	1.50	4.25	3.50
Range between min to max score	0.45	0.45	0.37	0.73	0.22
Significance (range more than 0.50 is considered significant)	Not significant	Not significant	Not significant	Significant	Not significant

Notation:

There was no respondents with 3-4 years period of service and only 1 respondent with 4-5 years period of service were recorded during the surveys. Thus, these types were excluded from Table III to eliminate bias.

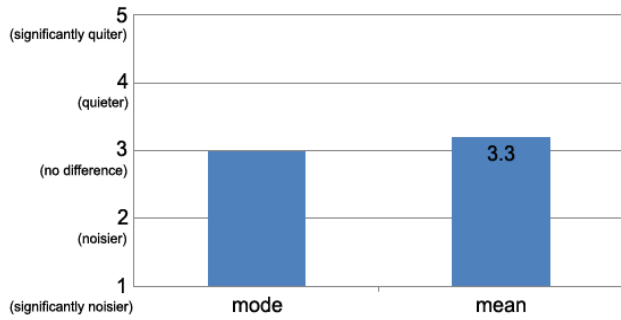


Fig. 17. Alstom office's judgment about noise annoyance during greenery

Further analysis was conducted to see whether there was any correlation between gender, age, period of service and the rest variables. From the point of view of gender, there was no valid deeper analysis might be conducted since female respondents was a significant minority-- only 4 of 41 respondents. The minority would lead to a bias finding. That is to be disregarded. From age point of view (Table II, Fig. 9, Fig. 19), we may learn that variables of judgment on existing noise and judgment on noise level during greenery installation have no correlation to the age of respondents. This is marked by similar rectangles size in the bar chart with differences between min and max score below 0.50.

Fig.19 shows a quite variation of rectangles size of level of distraction and preconception on greenery. This indicates that difference level of distraction and preconception on greenery were affected by the age of respondents. Significant difference is notified by the mode of age (36-40 years) which tends to have positive preconception than that of younger age (25-30 years) which tends to have no preconception on greenery reducing noise. From Table II, Fig.9 and Fig. 19, we may also learn that the mode felt higher level of distraction than the rest and age of 41-45 had more positive prior knowledge than the rest.

From period of service point of view, we mark that it seemed no correlation between period of service and other variables. This is represented by similar rectangles size in the bar chart and range of difference between min and max score below 0.50; with variable of preconception is an exception (Table III and Fig. 20). Respondents with period of service more than 5 years have more significant positive preconception than those with 2-3 years period of service, the difference was 0.73 point.

The findings of the questionnaire-type survey is interesting, since according to the meters, we may consider that there was no noise difference to respondents' auditory sensitivity, but they perceived that the noise had lowered. From this we learn that indoor greeneries may create the impression of lowered indoor noise. This perception might be supported by prior knowledge and preconception of respondents on greeneries.

There was also a question regarding respondents' expectation on the room's improvement that we may learn from. A question asked respondents whether they had any expectation on the room's improvement regarding to what they experienced currently. It was scaled from 1 to 4, which were "significantly need no improvement", "need no improvement",

"need improvement" and "significantly need improvement" respectively. This question was asked before installation of greenery and the survey scored 4 as the mode, means "significantly needs improvement" (Table I). When respondents judged that existing noise annoyance was "fair", but they expected a significant improvement, the "fair" judgment might not be of actual experience. Supported by findings on metered noise levels of both offices which were over the standard, the "fairness" judgment might be based upon adaptation to existing noise. The mode data on period of service which is 2–3 years has successfully built employees adaptation and tolerance to higher noise than they were supposed to be.

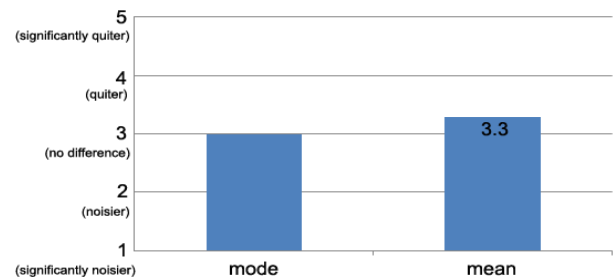


Fig. 18. Overall judgment about noise annoyance during greenery installation

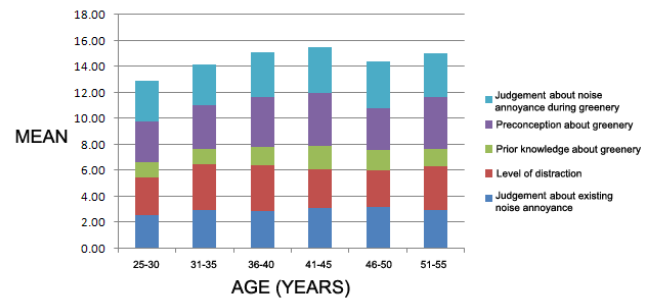


Fig. 19. Correlation between variable of age and other dependent variables

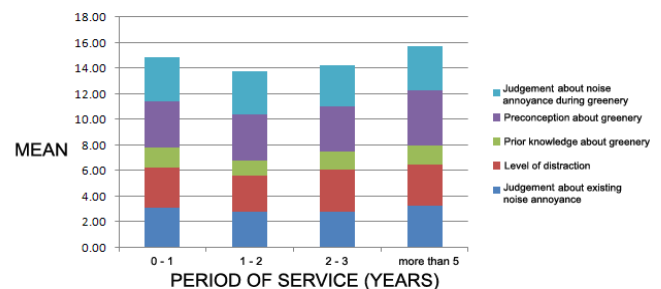


Fig. 20. Correlation between variable of period of service and other dependent variables

VI. CONCLUSION AND RECOMMENDATION

By this study we learn that incapability of greenery to reduce noise might be masked by respondents' prior knowledge and preconception on greenery. That is, judgment on a "quieter" office by indoor greenery was merely a perception, not a factual condition. We may consider that apart from acoustical findings on greenery, respondents' perceptions on greenery may be

useful to create more acceptable ambient indoor noise levels in open plan working spaces.

Further research to study more detail on the existence of direct and significant correlation among prior knowledge, the preconception on greenery and perception of indoor noise levels is recommended.

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